REMARKS

I. Amendment to the Claims

Upon entry of the foregoing amendment, twenty-two (22) claims are pending in the application. Of the pending claims, three (3) claims are independent. One (1) claim is newly added. Applicant submits that no new matter has been added and no fee is necessary for newly added Claim 39.

II. Claim Rejections under 35 U.S.C. § 102

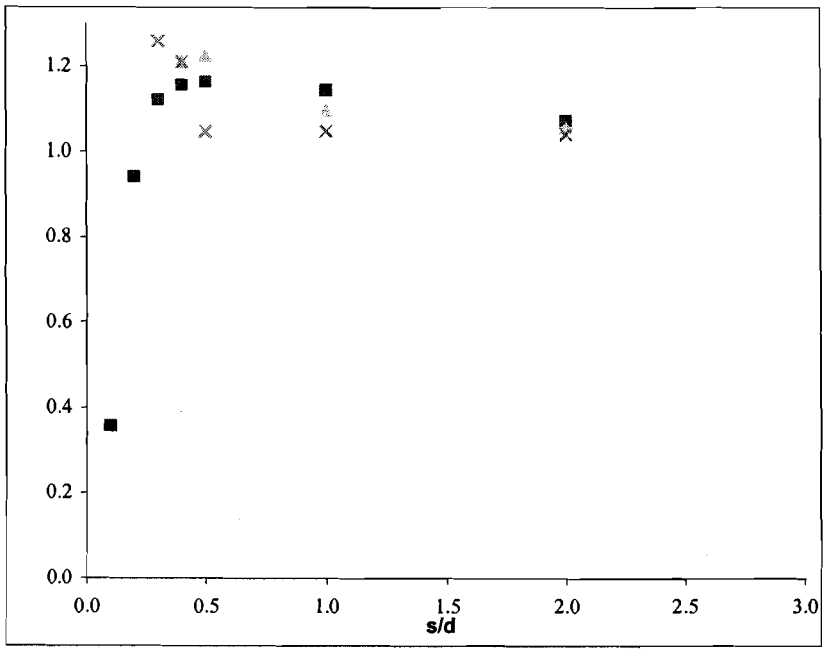
The Examiner has rejected Claims 3, 5, 8, 11, 20, 26, 34, 36, and 38 under 35 U.S.C. § 102(b) as being anticipated by U.S. Patent 1,736,635 to Steenstrup (hereinafter referred to as "Steenstrup"). The rejection is respectfully traversed.

The present invention includes a conduit defining a plurality of loops having a plurality of gaps therebetween, and a plurality of fins that extend radially beyond the outer extents of the conduit. Furthermore, the fins of the present invention are fundamentally different since they have openings that allow for the radial flow of air as well as axial flow of the air. Applicant submits that the cited art does not describe a plurality of fins that extend beyond an outer extent of a conduit or allow for the radial flow of air. Rather, the Steenstrup describes a plurality of fins that extend to, and terminate at, a conduit. The Steenstrup fins are further blocked by their fold and the casing on the inner-side and by their fold on the outer periphery. There can be no radial flow of air and as such this its application goes totally against why fins are used. Accordingly, Steenstrup does not describe the limitations of the claimed invention.

Further, the present invention provides a novel, useful, and non-obvious heat exchanger that has substantial advantages over conventional heat exchangers. These technical advantages

are not obvious even to experts in the field and go far beyond a reasonable expectation of success. Applicant submits that any differences between the claimed invention and the prior art may be expected to result in some differences in properties. (See MPEP 716.02) For example, "A greater than expected result is an evidentiary factor pertinent to the legal conclusion of obviousness ... of the claims at issue." *In re Corkill*, 711 F.2d 1496, 226 USPQ 1005 (Fed. Cir. 1985).

The graph below is a plot of the ratio of heat transfer coefficient for the helicoidal heat exchanger to that of a conventional heat exchanger as a function of the tube spacing to tube diameter ratio. As can be seen, there is an optimum spacing, when the gap between two adjacent tubes (tube spacing) is about 0.4 diameter of the pipe. At this optimum point, the heat transfer coefficient on the outside is approximately 20% higher than that of conventional heat exchangers. Beyond this point, as the tube spacing increases, there is no change in the heat transfer coefficient.



Further, in a typical conventional heat exchanger the tube diameter is about 3/8 inches and the tube spacing is about ¾ inches. Accordingly, in a typical heat exchanger with 11 rows, the height would be 11*(3/8+3/4) = 12.4 inches. However, a helicoidal heat exchanger can be built having a tube spacing of approximately 0.4*3/8 = 0.15 inches for a total height of 5.8 inches. This is more than a 50% reduction in the height of the heat exchanger. Hence the unexpectedly beneficial results of the effect of the spacing on heat exchange are embodied in the design as claimed.

Also, it has also been shown that an inside heat transfer coefficient is typically 20 to 40% higher. Therefore, the overall heat transfer coefficient given by

$$\frac{1}{h} = \frac{1}{h_{outside}} + \frac{1}{h_{inside}}$$

will also be 20% higher. Accordingly, the size of heat exchanger can be reduced by 20%, or one row could be eliminated, thereby making a substantial saving in size and material.

Additionally, the present invention has substantial advantages when it comes to pressure drop. A conventional heat exchanger having a total pipe length L is made up of N equal length (rows) each having a length L/N. Each tube segment is attached to the next by a U bend (hair pin). As such, a total of N-1 U bends are needed. The effective friction factor for this combination is

$$\frac{\Delta P_{conv}}{\rho g} = f_{straight}\frac{L}{d}\frac{V^2}{2g} + (N-1)K\frac{V^2}{2g} \qquad (2)$$

where K is the friction coefficient for the U bend. Calculating the ratio of the Pressure drop in a conventional heat to that of a straight pipe becomes

$$\frac{\Delta P_{Conv}}{\Delta P_{straight}} = 1 + (N-1)\frac{K}{f}\frac{d}{L} \qquad (3)$$

For a typical 18 inch long heat exchanger having 11 rows made of ½ inch pipe:

$$\frac{\Delta P_{Conv}}{\Delta P_{straight}} = 1 + (11-1)\frac{1.5}{.015}\frac{3/8}{18*11} = 2.89 \qquad (4)$$

However, for a helicoidal pipe of the same length the pressure drop is 20% to 30% higher than that in a straight pipe. Therefore comparing the above conventional heat exchanger to a helicoidal heat exchanger of the same length,

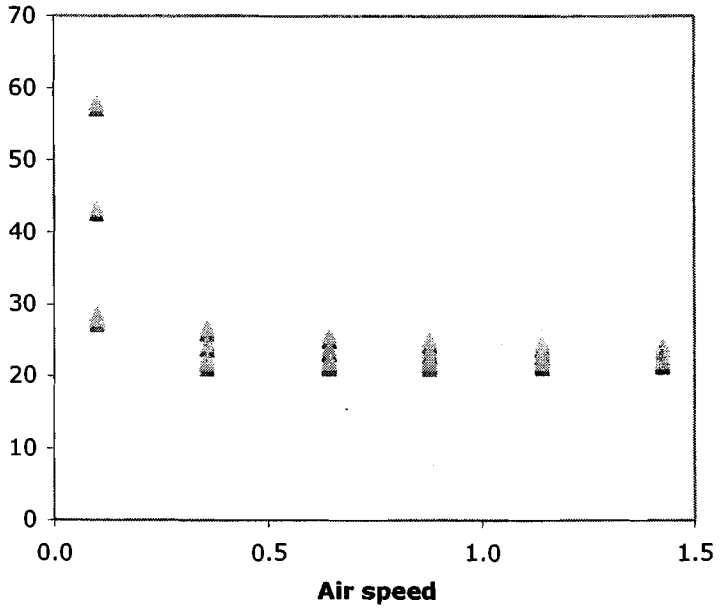
$$\frac{\Delta P_{heli}}{\Delta P_{Conv}} = \frac{1.3}{2.89} = 0.45$$

Accordingly, the pressure drop is less than half of a conventional heat exchanger. Thus the use of a smaller diameter pipe reduces overall size and material costs. Hence the unexpectedly beneficial results of the effect of the invention on pressure drop are embodied in the design as claimed.

Furthermore, excluding the fin width, since a finned helicoidal heat exchanger is round, for the same length, it will be about 1/3 as wide as a rectangular heat exchanger of equal tube. For example an 18 inch long heat exchanger will be around 6 inches wide. Therefore an 18x11 inch heat exchanger can be shrunk into a 5x6 inch heat exchanger. This reduction in length is accompanied by a proportionate increase in the depth. However, finned helicoidal heat exchangers allow the use of a sirocco fan (squirrel cage) blower in the center of the coil cavity.

Another important advantage of the invention is its ability to use a blower instead of a fan. This not only substantially reduces the overall size of the unit, since the blower is placed inside the coil cavity, it also provides for a far more uniform flow over the coil. The scroll cage

blower provides more uniform cooling. In conventional heat exchangers, a round fan is placed in front of rectangular heat exchangers leading to a large variation on the flow speed over conventional heat exchangers. Below is a plot of our experimental measurements of the average surface temperature of the heat exchanger as a function of air (blower) speed. As can be seen, the surface temperature drops substantially past the airflow rate of 0.4 m/s and stays constant after that. This means that the heat exchanger can overate with a much lower fan power.



Preliminary research work on measuring the heat transfer from the outside of the heat exchangers indicates that there may also be improvements due to the more uniform air flow. Also, due to the tubes curvature and wedge shape of the fins the outside heat transfer rate is also higher.

The helicoidal heat exchanger presently claimed embodies unexpectedly beneficial results in improving the efficiency of the vapor compression cycles, a dramatic reduction in the overall

use of electricity for air conditioning and a small foot-print of the proposed design allows the incorporation of other energy saving options.

These advantages of the present invention are not obvious, not only because no such product is on the market, but because some of the advantages are surprising. This air conditioner is completely practical and has numerous advantages over the conventional ones.

These advantages not only lead to improvements in conventional air conditioning systems and how they are utilized, but may be proven suitable for use in air conditioning systems that utilize alternative refrigerants like carbon dioxide and operate at elevated pressures, as well as automobile air conditioners since it has the potential to cut the size of an automobile air conditioner in half. Additionally the heat exchangers can be used in applications requiring high temperature and/or pressure such as fuel cells, next generation nuclear power plants, and so forth.

Given the unexpected results shown by the presently claimed invention, the prior art of record cannot disclose the invention as described. Rather, the unexpected differences in the properties of the claimed invention and the prior art render the claimed invention patentable over the cited art. Specifically, it is evident that if the present invention were not novel as suggested by the Examiner, the technology described in the present application would clearly be in everyday use today. The lack of technology similar to the present invention, in light of the present invention's superiority over known technology, clearly indicates that the present invention is novel over the cited art.

For at least these reasons, Applicant requests that the Section 102 rejection be withdrawn.

III. Claim Rejections under 35 U.S.C. § 103

The Examiner has rejected Claims 6, 12, and 23 under 35 U.S.C. §103(a) as being anticipated by Steenstrup in view of U.S. Patent No. 3,759,321 to Ares (hereinafter referred to as "Ares"). The rejection is respectfully traversed.

The Examiner has also rejected Claims 7 and 28 under 35 U.S.C. §103(a) as being anticipated by Steenstrup in view of U.S. Patent No. 2,673,074 to Dailey (hereinafter referred to as "Dailey"). The rejection is respectfully traversed.

Further, the Examiner has rejected Claims 33 and 37 under 35 U.S.C. §103(a) as being anticipated by Steenstrup in view of U.S. Patent No. 3,583,478 to Fieni (hereinafter referred to as "Fieni") or U.S. Patent No. 3,687,194 to Scholl (hereinafter referred to as "Scholl"). The rejection is respectfully traversed.

As set forth above, the present invention is submitted to be patentable over Steenstrup. Applicant submits that none of Ares, Dailey, Fieni, or Scholl makes up for the deficiencies of Steenstrup. Accordingly, Applicant submits that the present invention is patentable over the cited art and, therefore, requests that the Section 103 rejections be withdrawn.

IV. Conclusion

Applicant respectfully submits that the independent claims are allowable over the prior art of record, including the cited references. For similar reasons, and for the additional reasons set forth above, Applicant urges that the dependent claims are also allowable.

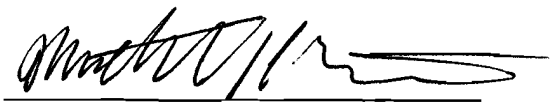
All of the stated grounds of rejection have been properly traversed, accommodated, or rendered moot. Applicant therefore respectfully requests that the Examiner reconsider all presently outstanding rejections and that they be withdrawn. It is believed that a full and

complete response has been made to the outstanding Office Action, and as such, the present application is in condition for allowance.

If the Examiner believes, for any reason, that personal communication will expedite prosecution of this application, the Examiner is invited to telephone the undersigned at the number provided.

Prompt and favorable consideration of this Amendment is respectfully requested.

Respectfully submitted,



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